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INVENTOR: Ulrich PEUCHERT and Peter BRIX  
TITLE: A FLAT PANEL LIQUID-CRYSTAL DISPLAY SUCH  
FOR A LAPTOP COMPUTER

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TC 1700

Greensburg, Pennsylvania 15601

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January 12, 2004

**TRANSLATOR'S VERIFICATION**

Sir:

I, Nils H. Ljungman, a patent attorney with Registration No. 25,997, registered to practice before the U.S. Patent and Trademark Office and an attorney-at-law with Registration No. 11328, registered to practice before the Supreme Court of Pennsylvania, declare that I am proficient in both the English and the German languages and am able to make accurate translations of patent and trademark subject matter from German into English. I have verified the translation of Federal Republic of Germany Patent Application No. 100 00 837, and I believe that the attached translation is an accurate, verified and true

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translation of the German language copy of Federal Republic of  
Germany Patent Application No. 100 00 837.

The undersigned declares further that all statements made herein  
of my own knowledge are true and that all statements made on  
information and belief are believed to be true; and further that these  
statements were made with the knowledge that willful false statements  
and the like so made are punishable by fine or imprisonment, or both,  
under Section 1001 of Title 18 of the United States Code and that  
such willful false statements may jeopardize the validity of the  
applications or any patents issuing thereon.

(Signature)   
Nils H. Ljungman, Esq.  
Patent Attorney  
Attorney-at-Law

(Date) January 12, 2004



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Patent Claims

- 5 1. Alkali-free aluminoborosilicate glass having a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.8 \cdot 10^{-6}/K$ , which has the following composition (in % by weight, based on oxide):

SiO <sub>2</sub>	> 58 - 65
B <sub>2</sub> O <sub>3</sub>	> 6 - 11.5
Al <sub>2</sub> O <sub>3</sub>	> 14 - 25
MgO	4 - 8
CaO	0 - 8
SrO	2.6 - < 4
BaO	0 - < 0.5
with SrO + BaO	> 3
ZnO	0 - 2

- 10 2. Alkali-free aluminoborosilicate glass having a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.4 \cdot 10^{-6}/K$ , which has the following composition (in % by weight, based on oxide):

15

SiO <sub>2</sub>	> 58 - 65
B <sub>2</sub> O <sub>3</sub>	> 6 - 11.5
Al <sub>2</sub> O <sub>3</sub>	> 14 - 25
MgO	4 - 8
CaO	0 - < 2
SrO	> 0.5 - < 4
BaO	0 - < 0.5
ZnO	0 - 2

- 20 3. Alkali-free aluminoborosilicate glass having a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.6 \cdot 10^{-6}/K$ , which has the following composition (in % by weight, based on oxide):

SiO <sub>2</sub>	> 58 - 65
B <sub>2</sub> O <sub>3</sub>	> 6 - 11.5
Al <sub>2</sub> O <sub>3</sub>	> 21 - 25
MgO	4 - 8
CaO	0 - 8
SrO	2.6 - < 8
BaO	0 - < 0.5
with SrO + BaO	> 3
ZnO	0 - 2

4. Aluminoborosilicate glass according to Claim 1 or 2, characterized in that it comprises more than 18% by weight, preferably at least 20.5% by weight, particularly preferably at least 21% by weight, of Al<sub>2</sub>O<sub>3</sub>.
5. Aluminoborosilicate glass according to at least one of Claims 1 to 4, characterized in that the glass comprises more than 8% by weight of B<sub>2</sub>O<sub>3</sub>.
6. Aluminoborosilicate glass according to at least one of Claims 1 to 5, characterized in that it additionally comprises:

ZrO <sub>2</sub>	0 - 2
TiO <sub>2</sub>	0 - 2
with ZrO <sub>2</sub> + TiO <sub>2</sub>	0 - 2
As <sub>2</sub> O <sub>3</sub>	0 - 1.5
Sb <sub>2</sub> O <sub>3</sub>	0 - 1.5
SnO <sub>2</sub>	0 - 1.5
CeO <sub>2</sub>	0 - 1.5
Cl <sup>-</sup>	0 - 1.5
F <sup>-</sup>	0 - 1.5
SO <sub>4</sub> <sup>2-</sup>	0 - 1.5
with As <sub>2</sub> O <sub>3</sub> + Sb <sub>2</sub> O <sub>3</sub> + SnO <sub>2</sub> + CeO <sub>2</sub> + Cl <sup>-</sup> + F <sup>-</sup> + SO <sub>4</sub> <sup>2-</sup>	0 - 1.5

7. Aluminoborosilicate glass according to at least one of Claims 1 to 6, characterized in that the glass is free of arsenic oxide and antimony oxide, apart from unavoidable impurities, and that it can be produced in a float plant.  
5
8. Aluminoborosilicate glass according to at least one of Claims 1 to 7, which has a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.6 \cdot 10^{-6}/K$ , a glass transition temperature  $T_g$  of  $> 700^\circ C$  and a density  $\rho$  of  $< 2.600 \text{ g/cm}^3$ .  
10
9. Use of the aluminoborosilicate glass according to at least one of Claims 1 to 8 as substrate glass in display technology.  
15
10. Use of the aluminoborosilicate glass according to at least one of Claims 1 to 8 as substrate glass in thin-film photovoltaics.

**Alkali-free aluminoborosilicate glasses, and uses  
thereof**

The invention relates to alkali-free aluminoboro-  
5 silicate glasses. The invention also relates to uses of  
these glasses.

High requirements are made of glasses for applications  
as substrates in flat-panel liquid-crystal display  
10 technology, for example in TN (twisted nematic)/STN  
(supertwisted nematic) displays, active matrix liquid  
crystal displays (AMLCDs), thin film transistors (TFTs)  
or plasma addressed liquid crystals (PALCs). Besides  
high thermal shock resistance and good resistance to  
15 the aggressive chemicals employed in the process for  
the production of flat-panel screens, the glasses  
should have high transparency over a broad spectral  
range (VIS, UV) and, in order to save weight, a low  
density. Use as substrate material for integrated  
20 semiconductor circuits, for example in TFT displays  
("chip on glass") in addition requires thermal matching  
to the thin-film material silicon which is usually  
deposited on the glass substrate in the form of  
amorphous silicon (a-Si) at low temperatures of up to  
25 300°C. The amorphous silicon is partially  
recrystallized by subsequent heat treatment at  
temperatures of about 600°C. Owing to the a-Si  
fractions, the resulting, partially crystalline poly-Si  
layer is characterized by a thermal expansion  
30 coefficient of  $\alpha_{20/300} \approx 3.7 \cdot 10^{-6}/K$ . Depending on the a-  
Si/poly-Si ratio, the thermal expansion coefficient  
 $\alpha_{20/300}$  may vary between  $2.9 \cdot 10^{-6}/K$  and  $4.2 \cdot 10^{-6}/K$ .  
When substantially crystalline Si layers are generated  
by high temperature treatments above 700°C or direct  
35 deposition by CVD processes, which is likewise desired  
in thin-film photovoltaics, a substrate is required  
which has a significantly reduced thermal expansion of  
 $3.2 \cdot 10^{-6}/K$  or less.

In addition, applications in display and photovoltaics technology require the absence of alkali metal ions. Sodium oxide levels of less than 1000 ppm as a result of production can be tolerated in view of the generally "poisoning" action due to diffusion of  $\text{Na}^+$  into the semiconductor layer.

It should be possible to produce suitable glasses economically on a large industrial scale in adequate quality (no bubbles, knots, inclusions), for example in a float plant or by drawing methods. In particular, the production of thin ( $< 1 \text{ mm}$ ) streak-free substrates with low surface undulation by drawing methods requires high devitrification stability of the glasses. Compaction of the substrate during production, in particular in the case of TFT displays, which has a disadvantageous effect on the semiconductor microstructure, can be countered by establishing a suitable temperature-dependent viscosity characteristic line of the glass: with respect to thermal process and shape stability, it should have a sufficiently high glass transition temperature  $T_g$ , i.e.  $T_g > 700^\circ\text{C}$ , while on the other hand not having excessively high melting and processing ( $V_A$ ) temperature, i.e. a  $V_A$  of  $\leq 1350^\circ\text{C}$ .

The requirements of glass substrates for LCD display technology or thin-film photovoltaics technology are also described in "Glass substrates for AMLCD applications: properties and implications" by J. C. Lapp, SPIE Proceedings, Vol. 3014, invited paper (1997), and in "Photovoltaik - Strom aus der Sonne" by J. Schmid, Verlag C. F. Müller, Heidelberg 1994, respectively.

The abovementioned requirement profile is fulfilled best by alkaline earth metal aluminoborosilicate glasses. However, the known display or solar cell

substrate glasses described in the following publications still have disadvantages and do not meet the full list of requirements:

5 Numerous documents describe glasses having low MgO contents: JP 9-169 538 A, JP 4-160 030 A, JP 9-100 135 A, EP 714 862 A1, EP 341 313 B1, US 5,374,595, WO 97/11919 and WO 97/11920. Such glasses, in particular those of EP 714 862 A1 and JP 9-169538 A, do  
10 not have the desired meltability, as is evident from very high temperatures at viscosities of  $10^2$  dPas and  $10^4$  dPas, and have a relatively high density. The same applies to the MgO-free glasses of DE 37 30 410 A1.

15 The glasses of US 5,374,595 have high BaO contents of 2 - 7 mol% which leads to undesirably high densities of these glasses. The same applies to the glasses of JP 61-132536 A, JP 8-295530 A, JP 9-48632 A and JP 9-156953 A.

20 Similarly, the glasses of JP 10-72237 A having high SrO contents have very high temperatures at viscosities of  $10^2$  dPas and  $10^4$  dPas, as is evident from the examples.

25 The same is true for glasses having low  $B_2O_3$  contents as described in JP 9-263421 A and JP 10-45422 A. The devitrification tendency will be disadvantageously high, in particular in combination with low BaO contents. On the other hand, excessively high  $B_2O_3$   
30 contents - such glasses are described, for example, in US 4,824,808 - are disadvantageous for the intended properties of high heat resistance and high chemical resistance, in particular to hydrochloric acid solutions.

35 Low- $SiO_2$  glasses do not have sufficient chemical resistance either, in particular when they contain relatively large amounts of  $B_2O_3$  and are low in alkaline



earth metals. This applies to the glasses of WO 97/11919 and EP 672 629 A2. The relatively SiO<sub>2</sub>-rich variants of the latter document have only low Al<sub>2</sub>O<sub>3</sub> levels, which is disadvantageous for the  
5 cristallization behaviour.

JP 9-123 33 A, which relates to glasses for hard disks, describes compositions of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, CaO and further optional components including B<sub>2</sub>O<sub>3</sub>. The glasses listed  
10 have high alkaline earth metal oxide contents and thus have high thermal expansion, which makes them unsuitable for use in LCD or PV technology. Their visual quality will probably also be inadequate.

15 DE 196 17 344 C1 and DE 196 03 698 C1 by the Applicant disclose alkali-free, tin oxide-containing, low-SiO<sub>2</sub> or SrO-free glasses having a coefficient of thermal expansion  $\alpha_{20/300}$  of about  $3.7 \cdot 10^{-6}/K$  and very good chemical resistance. They are suitable for use in  
20 display technology. However, since they must contain ZnO, they are not ideal, in particular for processing in a float plant. In particular at higher ZnO contents (> 1.5% by weight), there is a risk of formation of ZnO coatings on the glass surface by evaporation and  
25 subsequent condensation in the hot-shaping range.

WO 98/27019 describes glasses for display and photovoltaics applications having a low density and a high heat resistance. In these glasses, some of which  
30 have a high CaO content, the SrO and BaO contents are limited to a total of 3% by weight, which renders the glasses susceptible to crystallization.

DE 196 01 022 A1 describes glasses which are selected  
35 from a very wide composition range and which must contain ZrO<sub>2</sub> and SnO. The glasses, which, according to the examples, have a relatively high BaO content, tend

to exhibit glass defects because of the  $\text{ZrO}_2$  level which has to be present.

DE 42 13 579 describes glasses for TFT applications having a coefficient of thermal expansion  $\alpha_{20/300}$  of  $< 5.5 \cdot 10^{-6}/\text{K}$ , according to the examples of  $\geq 4,0 \cdot 10^{-6}/\text{K}$ . These glasses which have relatively high  $\text{B}_2\text{O}_3$  levels and relatively low  $\text{SiO}_2$  contents do not have a high chemical resistance, in particular to diluted hydrochloric acid.

In the unexamined Japanese publications JP 10-25132 A, JP 10-114538 A, JP 10-130034 A, JP 10-59741 A, JP 10-324526 A, JP 11-43350 A, JP 11-49520 A, JP 10-231139 A and JP 10-139467 A, mention is made of very wide composition ranges for display glasses, which can be varied by means of many optional components and which are admixed with one or more specific refining agents in each case. However, these documents do not indicate how glasses having the complete requirement profile described above can be obtained in a specific manner.

It is an object of the present invention to provide glasses which meet said physical and chemical requirements imposed on glass substrates for liquid-crystal displays, in particular for TFT displays, and for thin-film solar cells, in particular on the basis of  $\mu\text{c-Si}$ , glasses which have high heat resistance, a favourable processing range and sufficient devitrification stability.

The object is achieved by aluminoborosilicate glasses as defined in the independent Claims.

The glasses contain from  $> 58$  to  $65\%$  by weight of  $\text{SiO}_2$ . At a lower content, the chemical resistance is impaired, while at a higher content, the thermal expansion is too low and the crystallization tendency

of the glass increases. Preference is given to a content of up to 64.5% by weight of  $\text{SiO}_2$ .

The glasses contain from > 14 to 25% by weight of  $\text{Al}_2\text{O}_3$ .  
5  $\text{Al}_2\text{O}_3$  has a positive effect on the heat resistance of the glasses without excessively increasing the processing temperature. At a lower content, the glasses become more susceptible to crystallization. Preference is given to a content of more than 14.5% by weight of  
10  $\text{Al}_2\text{O}_3$ , particularly preferably more than 18% by weight of  $\text{Al}_2\text{O}_3$ , most preferably of at least 20.5% by weight of  $\text{Al}_2\text{O}_3$ , in particular of at least 21% by weight of  $\text{Al}_2\text{O}_3$ . Preference is given to a maximum  $\text{Al}_2\text{O}_3$  content of 24% by weight.

15 The  $\text{B}_2\text{O}_3$  content is restricted to a maximum of 11.5% by weight in order to achieve a high glass transition temperature  $T_g$ . Higher contents would also impair the chemical resistance. Preference is given to a maximum  
20  $\text{B}_2\text{O}_3$  content of 11% by weight. The  $\text{B}_2\text{O}_3$  content is higher than 6% by weight to ensure that the glasses have good meltability and good crystallization stability. Preference is given to a minimum content of more than 8% by weight.

25 The network-forming components  $\text{Al}_2\text{O}_3$  and  $\text{B}_2\text{O}_3$  are preferably present at mutually dependent minimum levels, ensuring a preferred content of the network formers  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  and  $\text{B}_2\text{O}_3$ . For example, in the case of  
30 a minimum  $\text{B}_2\text{O}_3$  content of > 6% by weight, the minimum  $\text{Al}_2\text{O}_3$  content is preferably > 18% by weight, and in the case of a minimum  $\text{Al}_2\text{O}_3$  content of > 14% by weight, the minimum  $\text{B}_2\text{O}_3$  content is preferably > 8% by weight.

35 The sum of  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  and  $\text{B}_2\text{O}_3$  is preferably between 83 and 91% by weight.

An essential glass component are the network-modifying alkaline earth metal oxides. In particular by varying their levels, a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.8 \cdot 10^{-6}/K$  is achieved. The individual oxides are present in the following proportions:

The glasses contain from 4 to 8% by weight of MgO. A high MgO level has a positive effect on the desired properties of low density and low processing temperature, whereas a rather low level favours crystallization stability and chemical resistance.

The glasses may contain up to 8% by weight of CaO. Higher levels would lead to an excessive increase in thermal expansion and a decrease in crystallization stability. For glasses exhibiting a particularly low thermal expansion, i.e. in particular for glasses having coefficients of thermal expansion  $\alpha_{20/300}$  of up to  $3.4 \cdot 10^{-6}/K$ , the CaO content is preferably limited to a maximum of < 2% by weight.

Another optional constituent is BaO, its maximum content being limited to less than 0.5% by weight. This ensures good meltability and keeps the density low. The glass is preferably BaO-free.

The glass contains up to < 4% by weight of the relatively heavy alkaline earth metal oxide SrO. Limitation to this low maximum content is especially advantageous for a low density of the glass.

When the minimum sum of SrO and BaO is more than 3% by weight in order to ensure sufficient crystallization stability, in particular with rather CaO-rich compositions, the minimum SrO content is 2.6% by weight.

In the case of low-CaO and CaO-free variants, in particular at CaO contents of between 0 and < 2% by weight, a minimum SrO content of at least > 0.5% by weight is sufficient. In the case of these glasses, the  
5 sum of SrO and BaO is preferably at least 1% by weight, particularly preferably at least > 1% by weight.

In the case of high Al<sub>2</sub>O<sub>3</sub> contents, i.e. contents of > 21% by weight, the SrO content can be varied within  
10 wider limits, between 2.6 and < 8% by weight. As a result of, in particular, the high SrO contents which have now become possible, particularly crystallization-stable glasses having sufficiently low densities are obtained. In the case of these glasses, the minimum sum  
15 of SrO and BaO is likewise > 3% by weight. These glasses have coefficients of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.6 \cdot 10^{-6}/K$ .

The glasses may contain up to 2% by weight of ZnO, preferably < 2% by weight of ZnO. The network modifier  
20 ZnO has a structure-loosening function and has less effect on the thermal expansion than the alkaline earth metal oxides. Its effect on the viscosity characteristic line is similar to that of B<sub>2</sub>O<sub>3</sub>. In  
25 particular in the case of processing of the glasses by the float process, the ZnO level is preferably limited to a maximum of 1.5% by weight. Higher levels would increase the risk of unwanted ZnO coatings on the glass surface which may form by evaporation and subsequent  
30 condensation in the hot-shaping range.

The glasses are alkali-free. The term "alkali-free" as used herein means that they are essentially free from  
alkali metal oxides, although they can contain  
35 impurities of less than 1000 ppm.

The glasses may contain up to 2% by weight of ZrO<sub>2</sub> + TiO<sub>2</sub>, where both the TiO<sub>2</sub> content and the ZrO<sub>2</sub> content

can each be up to 2% by weight.  $ZrO_2$  advantageously increases the heat resistance of the glasses. Owing to its low solubility,  $ZrO_2$  does, however, increase the risk of  $ZrO_2$ -containing melt relicts, so-called zirconium nests, in the glass.  $ZrO_2$  is therefore preferably omitted. Low  $ZrO_2$  contents originating from corrosion of zirconium-containing trough material are entirely unproblematic.  $TiO_2$  advantageously reduces the solarization tendency, i.e. the reduction in transmission in the visible wavelength region because of UV-VIS radiation. At contents of greater than 2% by weight, colour casts can occur due to complex formation with  $Fe^{3+}$  ions which are present in the glass at low levels as a result of impurities of the raw materials employed.

The glasses may contain conventional refining agents in the usual amounts: they may thus contain up to 1.5% by weight of  $As_2O_3$ ,  $Sb_2O_3$ ,  $SnO_2$  and/or  $CeO_2$ . It is likewise possible to add 1.5% by weight each of  $Cl^-$  (for example in the form of  $BaCl_2$ ),  $F^-$  (for example in the form of  $CaF_2$ ) or  $SO_4^{2-}$  (for example in the form of  $BaSO_4$ ). The sum of  $As_2O_3$ ,  $Sb_2O_3$ ,  $CeO_2$ ,  $SnO_2$ ,  $Cl^-$ ,  $F^-$  and  $SO_4^{2-}$  should, however, not exceed 1.5% by weight.

If the refining agents  $As_2O_3$  and  $Sb_2O_3$  are omitted, these glasses can be processed not only using a variety of drawing methods, but also by the float method.

For example with regard to easy batch preparation, it is advantageous to be able to omit both  $ZrO_2$  and  $SnO_2$  and still obtain glasses having the property profile mentioned above, in particular having high heat and chemical resistance and low crystallization tendency.

## Working examples:

Glasses were produced in Pt/Ir crucibles at 1620°C from conventional raw materials which were essentially alkali-free apart from unavoidable impurities. The melt was refined at this temperature for one and a half hours, then transferred into inductively heated platinum crucibles and stirred at 1550°C for 30 minutes for homogenization.

10

The Table shows fourteen examples of glasses according to the invention with their compositions (in % by weight, based on oxide) and their most important properties. The refining agent SnO<sub>2</sub> (Examples 1, 2, 4, 5, 7, 8, 10-14) or As<sub>2</sub>O<sub>3</sub> (Examples 3, 6, 9) at a level of 0.3% by weight is not listed. The following properties are given:

- the coefficient of thermal expansion  $\alpha_{20/300}$  [ $10^{-6}/K$ ]
- 20 • the density  $\rho$  [ $g/cm^3$ ]
- the dilatometric glass transition temperature  $T_g$  [°C] in accordance with DIN 52324
- the temperature at a viscosity of  $10^4$  dPas (referred to as  $T_4$  [°C])
- 25 • the temperature at a viscosity of  $10^2$  dPas (referred to as  $T_2$  [°C]), calculated from the Vogel-Fulcher-Tammann equation
- the refractive index  $n_d$
- the resistance to buffered hydrofluoric acid ("BHF") as weight loss (material removal value) from glass plates measuring 50 mm x 50 mm x 2 mm and polished on all sides after treatment with 10% strength NH<sub>4</sub>F·HF solution for 20 minutes at 23°C [ $mg/cm^2$ ].
- 30

## Table

Examples: Compositions (in % by weight, based on oxide) and essential properties of glasses according to the invention.

	1	2	3	4	5	6	7
SiO <sub>2</sub>	58.3	58.3	63.5	62.1	62.1	63.5	60.8
B <sub>2</sub> O <sub>3</sub>	8.5	8.5	9.0	8.2	8.2	9.1	8.2
Al <sub>2</sub> O <sub>3</sub>	21.5	21.5	16.5	19.0	19.0	17.3	16.1
MgO	4.5	6.0	4.5	6.0	7.5	6.0	4.1
CaO	3.4	1.9	3.0	1.5	1.5	1.8	7.0
SrO	3.5	3.5	3.2	2.0	1.0	2.0	3.5
BaO	-	-	-	0.4	0.4	-	-
ZnO	-	-	-	0.5	-	-	-
$\alpha_{20/300}$ [ $10^{-6}/K$ ]	3.26	3.16	3.14	2.96	2.99	2.98	3.76
$\rho$ [g/cm <sup>3</sup> ]	2.48	2.47	2.43	2.45	2.44	n.m.	2.49
T <sub>g</sub> [°C]	735	737	723	740	729	725	713
T <sub>4</sub> [°C]	1257	1273	1300	1283	1288	1289	1255
T <sub>2</sub> [°C]	1613	1621	1694	1657	1652	1653	1616
n <sub>d</sub>	1.522	1.522	1.513	1.516	1.516	1.520	1.524
BHF [mg/cm <sup>2</sup> ]	0.71	0.77	0.58	0.65	0.66	0.60	0.60

n.m. = not measured



Continuation of table:

	8	9	10	11	12	13	14
SiO <sub>2</sub>	59.5	60.0	60.0	52.5	60.0	60.0	62.6
B <sub>2</sub> O <sub>3</sub>	7.5	7.5	6.6	7.5	7.5	10.0	8.2
Al <sub>2</sub> O <sub>3</sub>	21.5	21.5	22.5	18.5	18.5	16.0	14.5
MgO	4.5	4.1	6.0	4.5	5.6	4.2	4.2
CaO	0.4	3.5	1.1	3.2	4.2	6.0	6.7
SrO	6.0	2.7	3.5	3.5	3.9	3.5	3.5
BaO	0.3	0.4	-	-	-	-	-
ZnO	-	-	-	-	-	-	-
$\alpha_{20/300}$ [ $10^{-6}/K$ ]	3.04	3.12	3.00	3.19	3.55	3.64	3.72
$\rho$ [g/cm <sup>3</sup> ]	2.49	2.47	2.48	2.46	2.50	2.47	2.47
T <sub>g</sub> [°C]	742	746	753	730	730	700	705
T <sub>4</sub> [°C]	1287	1284	1286	1294	1253	1234	1252
T <sub>2</sub> [°C]	1654	1644	1641	1674	1615	1604	1627
n <sub>d</sub>	1.518	1.520	1.521	1.522	1.524	1.521	1.520
BHF [mg/cm <sup>2</sup> ]	0.81	0.66	0.78	n.m.	n.m.	n.m.	0.58

Furthermore, acid resistance was determined for the glasses of examples 3 and 14, i.e. the "HCl" acid resistance as weight loss (material removal value) from glass plates measuring 50 mm x 50 mm x 2 mm and polished on all sides after treatment with 5% strength hydrochloric acid for 24 hours at 95°C: it was found to be 0.78 mg/cm<sup>2</sup> (glass no. 3) and 0.50 mg/cm<sup>2</sup> (glass no. 14), respectively.

As the working examples illustrate, the glasses according to the invention have the following advantageous properties:

- a thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.8 \cdot 10^{-6}/K$ , or between  $2.8 \cdot 10^{-6}/K$  and  $3.6 \cdot 10^{-6}/K$ , or up to  $3.4 \cdot 10^{-6}/K$ , respectively, thus matched to the expansion behaviour of both amorphous silicon and increasingly polycrystalline silicon.
- $T_g > 700^\circ C$ , a very high glass transition temperature, i.e. a high heat resistance. This is essential for the lowest possible compaction as a result of production and for use of the glasses as substrates for coatings with amorphous Si layers and their subsequent annealing.

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- $\rho < 2500 \text{ g/cm}^3$ , a low density

- a temperature at a viscosity of  $10^4$  dPas of at most  $1350^\circ C$ , and a temperature at a viscosity of  $10^2$  dPas of at most  $1720^\circ C$ , which means a suitable viscosity characteristic line with regard to hot-shaping and meltability. The glasses can be produced as flat glasses by the various drawing methods, for example microsheet down-draw, up-draw or overflow fusion methods, and, in a preferred embodiment, if they are free from  $As_2O_3$  and  $Sb_2O_3$ , also by the float process.

- a high chemical resistance, as is evident from good resistance to buffered hydrofluoric acid solution, which makes them sufficiently inert to the chemicals used in the production of flat-panel screens.

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- $n_d \leq 1.526$ , a low refractive index. This property is the physical prerequisite for a high transmission.

10 The glasses have high thermal shock resistance and good devitrification stability.

The glasses are thus highly suitable for use as substrate glass in display technology, in particular for TFT displays, and in thin-film photovoltaics.

ABSTRACT

The invention relates to an alkali-free aluminoborosilicate glass having a coefficient of thermal expansion  $\alpha_{20/300}$  of between  $2.8 \cdot 10^{-6}/K$  and  $3.8 \cdot 10^{-6}/K$ , which has the following composition (in % by weight, based on oxide):  $SiO_2 > 58 - 65$ ,  $B_2O_3 > 6 - 11.5$ ,  $MgO 4 - 8$ ,  $BaO 0 - < 0.5$ ,  $ZnO 0 - 2$  and  $Al_2O_3 > 14 - 25$ ,  $CaO 0 - 8$ ,  $SrO 2.6 - < 4$ , with  $BaO + SrO > 3$ , or  $Al_2O_3 > 14 - 25$ ,  $CaO 0 - < 2$ ,  $SrO > 0.5 - < 4$ , or  $Al_2O_3 > 21 - 25$ ,  $CaO 0 - 8$ ,  $SrO > 2.6 - < 8$ , with  $BaO + SrO > 3$ , and which is highly suitable for use as a substrate glass both in display technology and in thin-film photovoltaics.